TEST OF AN OLD BELT

R. B. KLEINERT

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TEST
OF AN
OLD BELT

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K. Ralph Becker
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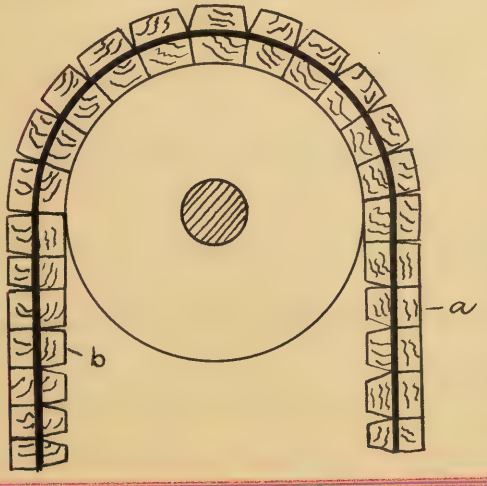
The object of this thesis was to test an old belt and compare it with a new belt. The simplest mode of transferring motion from one shaft to another is by belt and pulleys. The motion is transferred by the frictional adhesion between the surfaces in contact of the belt and pulleys so that the friction must be greater than the tension of the belt otherwise the belt will slip and fail to transmit all the motion due from the driving pulley. There is always some slip, so this mode of transmission is not positive

or exact and cannot be used where precise motions are required, but this slip does not exceed 2 or 3% under ordinary circumstances.

The length of a belt should be such that it will adhere to the pulley enough to prevent it from slipping and that without the necessity of bringing extra wear on the bearings. Every belt to run easily and well should be so slack when running that the slack side should run with a waving undulating motion the greater tension being on the leading side. A belt may be heavily loaded yet if at

every revolution it can have an opportunity for relief from its tension so as to contract to its natural texture, it will prevent it from breaking by the stress upon it. But if it be kept strained so tensely as to be constantly strained to its greatest extent on both sides of the pulley, it will wear but a short time without cracking at the edges and it will shortly be destroyed.



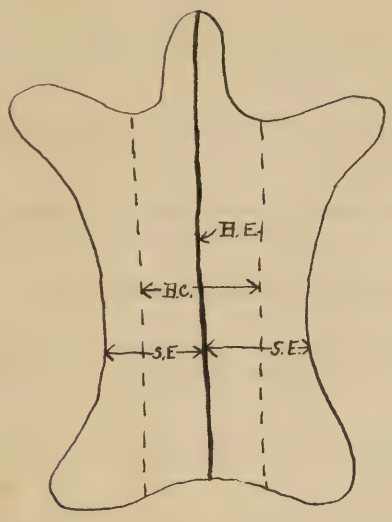
The change that is continually going on in thick belts passing round the circumference

of a wheel is best illustrated by the figure. It consists of a thin belt and a continuous row of incompressible wooden blocks The parting of the outside row (a) of blocks while passing over the pulley shows how the outer parts of the belt are distended; and the reduction of the inside row (b) of blocks shows how the inner parts are relaxed.
Considering a section of the belt to be rectangular, the force expended in making these changes is proportional to the breadth, square of the thickness, and inversely to the diameter of the wheel. If two belts be of like strength but the one broad

and thin, the other narrow and thick, the amounts of force expended in bending them must be proportional directly to the square of their thickness, hence the broad thin belt is more advantageous than the narrow thick belt.

The strongest fibres in belt leather are near the flesh side about one-third of the way through from that side; the looser fibres are found near the hair side. In making a double ply belt, the two flesh sides of the two plies are placed facing each other and cemented together, this leaves the two hair sides on the outside of

the finished belt. There has been much difference of opinion as to which side of the belt should run on the pulley face, but with the hair side running on the pulley, you have the strongest part of the belt subject to the least wear, for, when the belt begins to wear, the outside fibres being the short fibres of the hair side, will be destroyed first, leaving the longer fibres of the flesh side, which are the strongest, to deliver the required power. The hair side being smoother than the flesh side, it will hug closer to the pulley, give greater driving power and is less liable to slip.



The figure shows the skin of the animal ready for tanning. The <u>hide</u> is the skin of the animal tanned whole.

The <u>back</u> is in the centre lengthwise of the hide.

The <u>sides</u> are the halves of the hide made by cutting down the middle of the back.

H.C. is the back centre.

S.E. is the side edge.

The ordinary way of making two-ply belts is by stripping pieces of the width required from the centres of the

hides, skiving the ends and on this one ply build up layer after layer, as many as are required, lengthwise of the belt. This brings the B.C. or firmest part of the leather immediately in the centre of the belt, the edges being composed of leather from the side portions of the hide, which is yielding in comparison with the middle portion.

Pulleys generally having convex faces, the middle of the belt being firm and not conforming to this convexity and the edges of comparatively loose fibre, the consequence is that the belt will not bind down to the edges of the pulley and will

stretch more owing to their loose fibre. Only a part of the width of the belt is effective, transmitting much less power than if all the surface contact was fully available.

The centre or tight portion of the belt bearing the greater part of the strain and the other parts not relieving it, will consequently give out sooner than if the strain was equalized. Along the portion of the hide over the back-bone, full or humpy places are found, being caused by the shape of the animal. This portion being hard and stubborn cannot be made flat and presents uneven surfaces along the centre of the belt, which

will never lie down flat to the pulley.

This wide double belt is made by cutting the hide along the middle, turning the H.E. outward and the S.E. inward joined by a scarfed lap, using a S.C. piece to breale joints widthwise. On this belt, the edge portions being of firm and unyielding leather and the middle portions of looser fibre of more yielding texture, there will be a giving to the higher part of the pulley. When the middle becomes stretched and allows the edge portions to bed themselves down to the pulley, the working strain

will be distributed over the entire width, preventing wear on any one part alone.

The adhesiveness of the belt and pulley is increased by softness and pliableness over those which are dry and lusterless.

Care should be taken in the application of oils to belts, for the pores of the leather become opened and the adhesion of the parts destroyed, rendering the belt flaccid and rotten.

Plate 1 page 24 shows the front side, edge and back of the old belt. By looking at the edge, the manner in which the joints are made is most plainly seen. This belt was one which had been run

from February 1893 until November 1903 in the University of Pennsylvania Light and Heat Station on the Porter - Allen Engine. The fly-wheel of this engine 73 inches diameter making 245 revolutions per minute. The horse-power transmitted by the belt varied from time to time.

During the first three years of service it was run on light loads transmitting about 44 HP, which reduces to a pull of 36.1 # per inch of width. In 1896, the power required by the University buildings was greatly increased by the addition of the Dormatories. During the winter of this year the machines were run to their utmost capacity and the belt delivered about 87. HP.; very near double the amount when

running normally. The machine was not used all day, but would run about 6 hours when another machine would be thrown in and the first one taken out, or, if the demand was heavy, the several machines would be run together, each one taking its share of the load. Some days this belt would not be run at all and during three months of this year the belt was thrown off entirely. When the machine was thrown on for the day, during the first hour the load was generally light, but during the second, third etc. hours the belt would transmit from 69 to 89 HP. During the winter of the next year, it transmitted the greatest power, reaching 103. HP which reduces to a pull of 85.8# per inch of width. During the summer the load dropped

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off so that the machine was only run at intervals. The average load was about 50 HP which reduces to a pull of 41# per inch of width. Although the load rose above this, yet not to so great an extent as in previous years. It was always during the winter that its use was required the most.

On July 11, 1902, a new piece about one foot long was spliced in one ply, and in November 1903, the old belt was taken off and a new one substituted.

From the dimensions plate 1, the belt was 36' long 8½" wide and 3/16" thick. It had received belt dressing from time to time and in a few places cracks were to be seen.

The outer edge on each side was pegged the whole length of the belt. Plate 2 page 25, shows the joint in the new belt.

It was 4' long $8\frac{1}{2}$" wide and $\frac{3}{8}$" thick; both of these belts being double-ply. It was cut out of the best part of the hide consequently it was a sample of what the best belt would stand.

The machine used to test the specimens of belting was the Olsen's Testing Machine. The motor is shown at 1, controller at 2. The speed of the machine is varied by means of the handle H. There are two pairs of cone pulleys over which the belt shown at 3 passes. By turning the

handle H the upper pair of pulleys are moved apart, also the lower pair, but the distance between centres remains the same. The upper pair are the drivers, so the belt will rise, making the lower pair equivalent to smaller pulleys, which will cause the lower shaft to revolve at a faster rate. By means of the lever 4, a friction clutch at the back of the machine is thrown in. A pinion on the shaft gears with the gear-wheel 5, which, by a system of gearing, transmits the load to the specimen by causing the piece 6 to descend. One end of the specimen is fastened in the piece 6 by flat grips, while the other end is fastened to the

part of the machine shown at 7 by another pair of flat grips. By means of the controller handle 2, the direction of the current through the motor 1 is changed, this enables the piece 6 to be moved upward. The stress upon the specimen is transferred by a system of levers and knife edges to the lever 8. On the right side of this lever is the scale-beam reading in thousand pounds, while 9 is a circular disc graduated in a thousand parts, so that by turning the wheel 10, it moves the piece 11 along the scale-beam until the load is balanced, and the value ascertained to the pound.

The work consisted in cutting specimens out of various parts

of the belt and finding how much pull they would stand before they broke.

OLT BELT

26-30 INC.	36-40 INC	41-45 INC	MEAN
878	860	890	876
1020	916	960	965
948	752	742	814
1038	745	1100	961
740	653	960	784

NEW BELT

6'-10' INC
2010
2085
2060
2000
1905

These values show the values reduced to one inch of width at which the pieces, numbered on the top line and seen on plates 1 and 2, broke. These specimens were cut out of the best part of the belt. The curves page 23 were plotted with the mean values of the old belt, and the top curve shows the curve of strength across the new belt.

OLD BELT

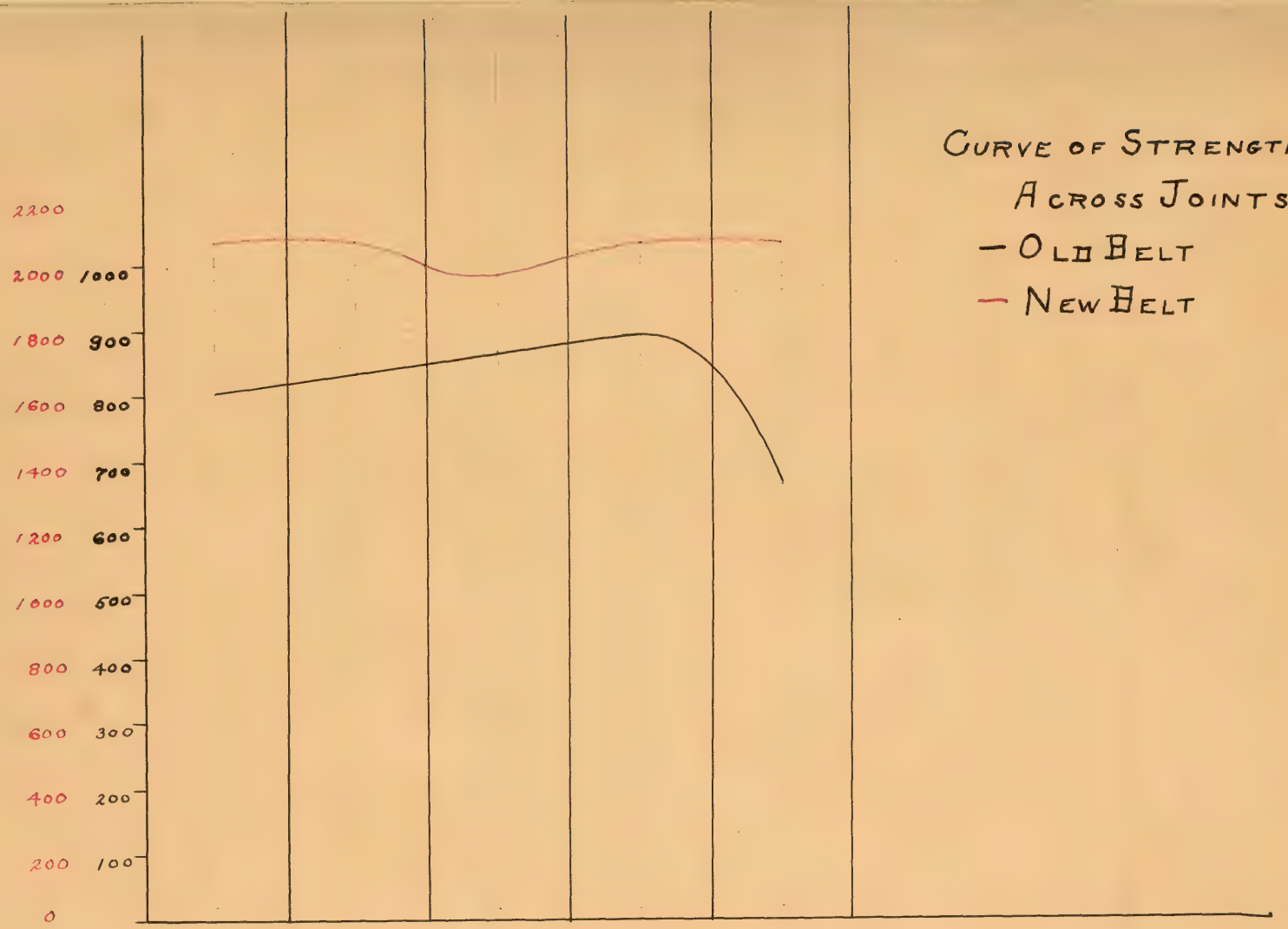
1–5 INC.	6–10 INC	11–15 INC	16–20 INC.	MEAN
644	792	1175	613	806
771	858	825	895	835
707	800	860	1110	869
788	957	761	1060	892
604	695	628	721	662

NEW BELT

1'-5' INC.
2090
2095
1955
2080
2080

These values show the values reduced to one inch of width at which the pieces, numbered on the top line and seen on plate 1, broke. On the old belt these specimens were 16" long and were cut so that the joints of the belt would be in the centres of the specimens. 3" was left on each side for gripping, leaving 10" for testing. On the new belt the specimens were 16" long and $\frac{3}{8}$" thick, those in the old belt being $\frac{3}{16}$": in this also the joints came in the

centres of the test pieces as seen on plate 2. With the mean of the four values, and those for the new belt, the two curves of strength across the belts were drawn, the one in red ink being for the new belt; the other one for the old belt. On page 22 this curve is shown. The five widths were laid off as abecissa, and these were bisected and ordinates drawn. The values from the table page 20 were then laid off and the curves drawn through these points. The new belt was weakest in the middle across the joint. The old belt was weakest on the lower side.


Curve of Strength
Across Joints
— Old Belt
— New Belt
2200
2000 1000
1800 900
1600 800
1400 700
1200 600
1000 500
800 400
600 300
400 200
200 100
0

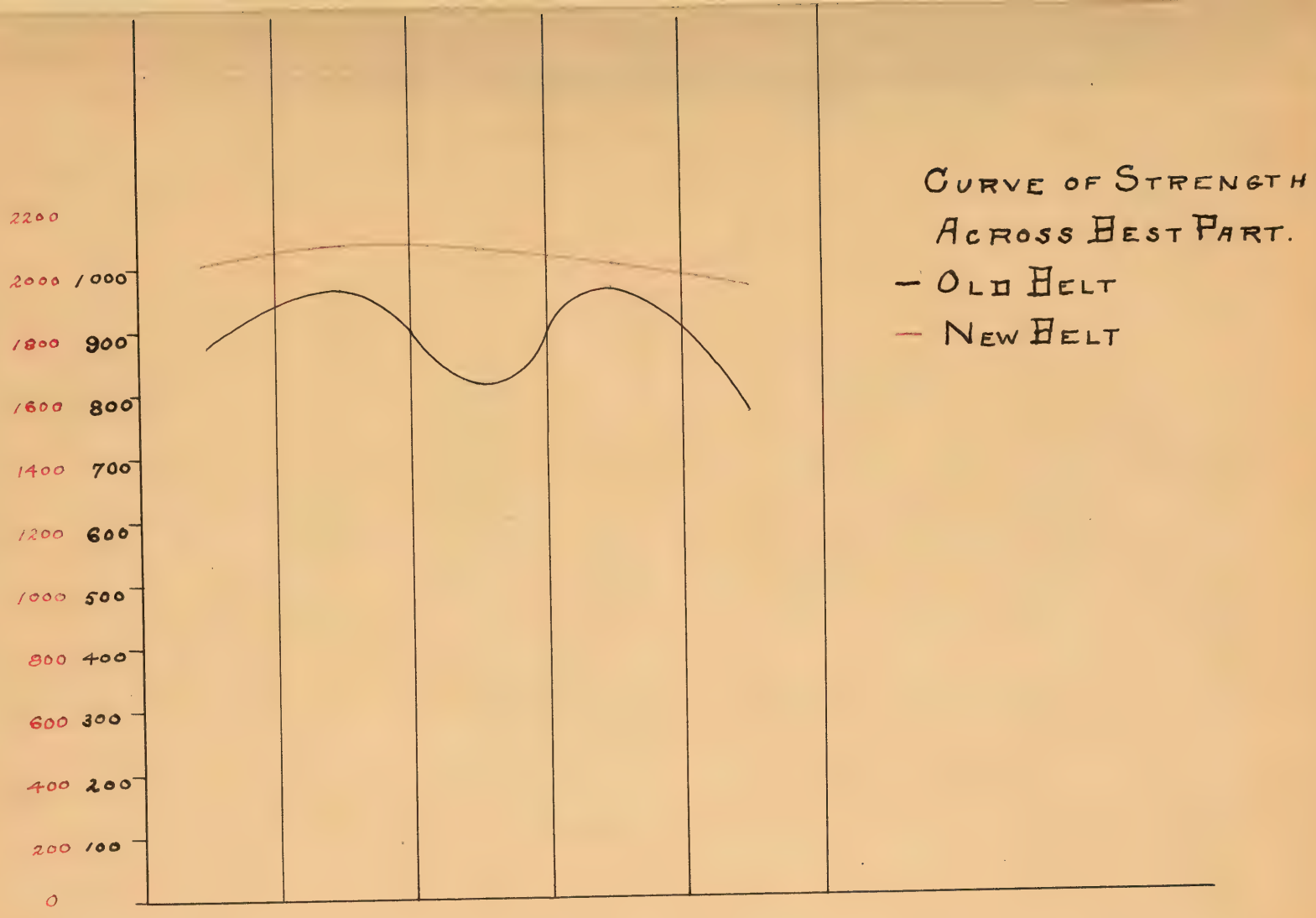
Curve 2

OLD BELT

31	32	33	34	35	MEAN
580	200	862	580	592	563

These values show the values reduced to one inch of width at which the pieces numbered on the top line and seen on plate 2, broke.

The tests on these pieces were made because it seemed to be the poorest part of the belt. Besides looking very weak, there was a crack, extending nearly through the one ply. #32 which broke at 200# gave way because of a peg hole.


2200
2000 1000
1800 900
1600 800
1400 700
1200 600
1000 500
800 400
600 300
400 200
200 100
0
Curve of Strength
Across Best Part.
— Old Belt
— New Belt

Curve 1

21		22		23		24		25	
EXTENS	LOAD	EXTENS	LOAD	EXTENS	LOAD	EXTENS	LOAD	EXTENS	LOAD
8.00"	0	8.00"	0	8.00"	0	8.00"	0	8.00"	0
.06	100	.07	115	.05	95	.07	100	.06	95
.11	200	.11	200	.11	200	.15	220	.13	200
.16	320	.15	300	.16	325	.19	300	.16	290
.20	420	.20	415	.20	425	.24	410	.23	385
.24	515	.24	515	.23	515	.27	520	.28	510
.28	610	.27	620	.26	610	.31	625	.33	650
.33	725	.31	730	.30	720	.36	730	.40	815
.37	815	.34	825	.34	825	.40	825	.45	910
.42	920	.38	935	.38	925	.45	920	.50	995
.50	1020	.44	1040	.43	1030	.50	1010	.57	1120
.55	1110	.49	1120	.46	1110	.57	1140	.65	1210
.62	1215	.53	1220	broke	1120 600	.62	1225	broke	1170
.66	1295	.59	1300			.68	1300		
broke	1320	broke	1440			broke	1395		

These pieces were cut 16" long and 2" wide and the extensions measured about every hundred pounds. Piece

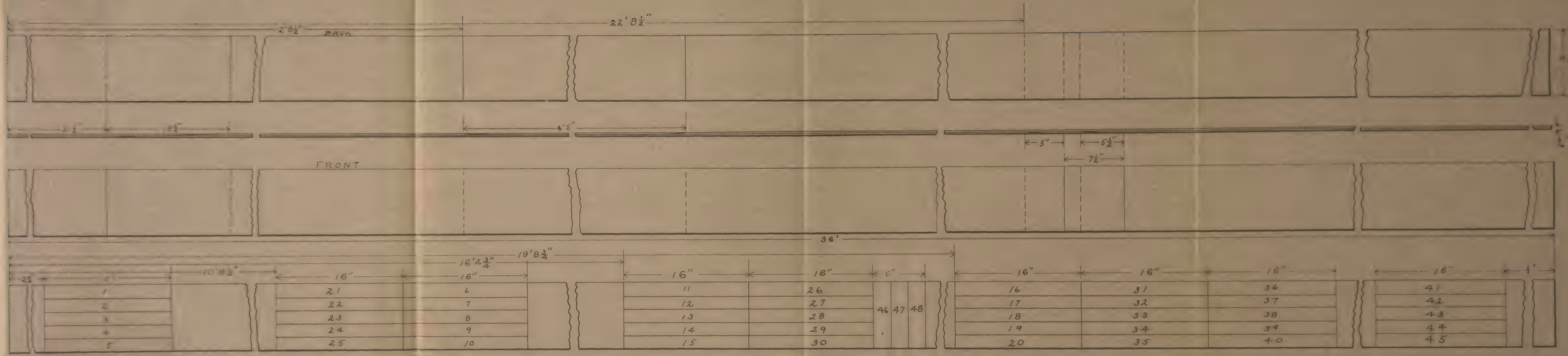
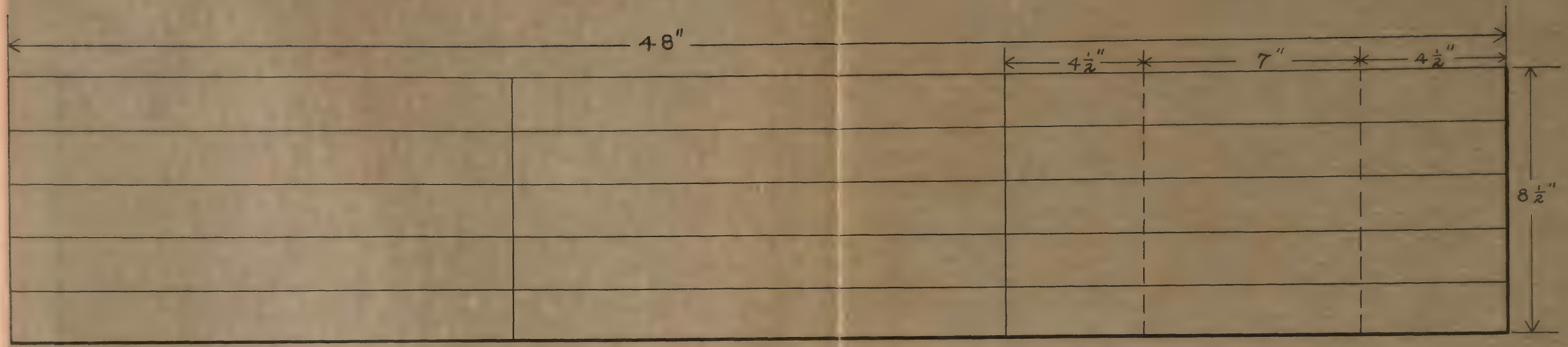


PLATE 1 SCALE 1½ IN.=1FT.

#23 broke up near the jaws of the machine. The first ply gave way at 1120# total load (all these values being actual loads and not in per inch of width) while the second ply was tested for ultimate strength and was found to breale at 600#.

The extensions were measured from 8" original length. Two marks eight inches apart were stepped off with dividers, the specimen placed in the machine and loads applied, and the dividers were set on the two marks, then applied to a steel rule reading to hundredths of an inch. By this means the extension could be found for any load.



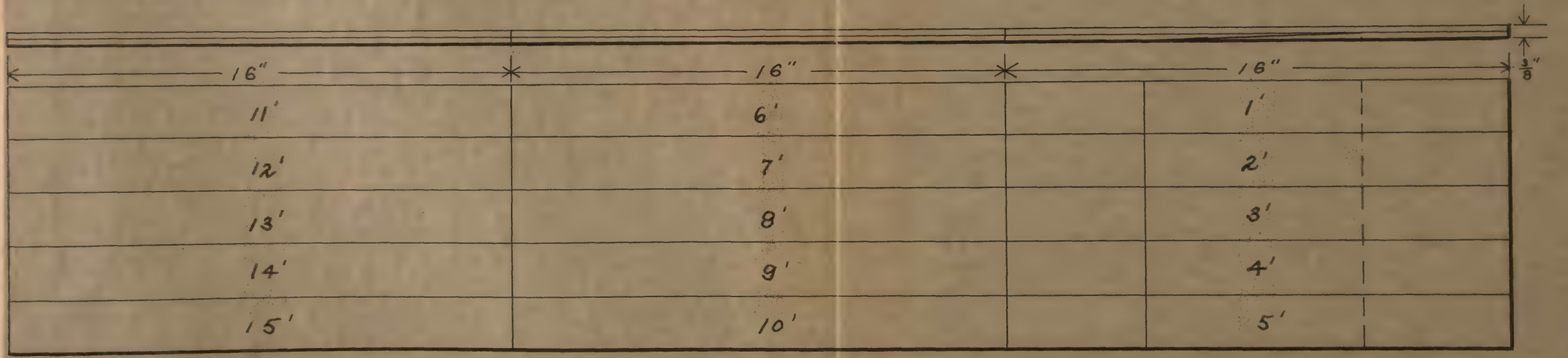
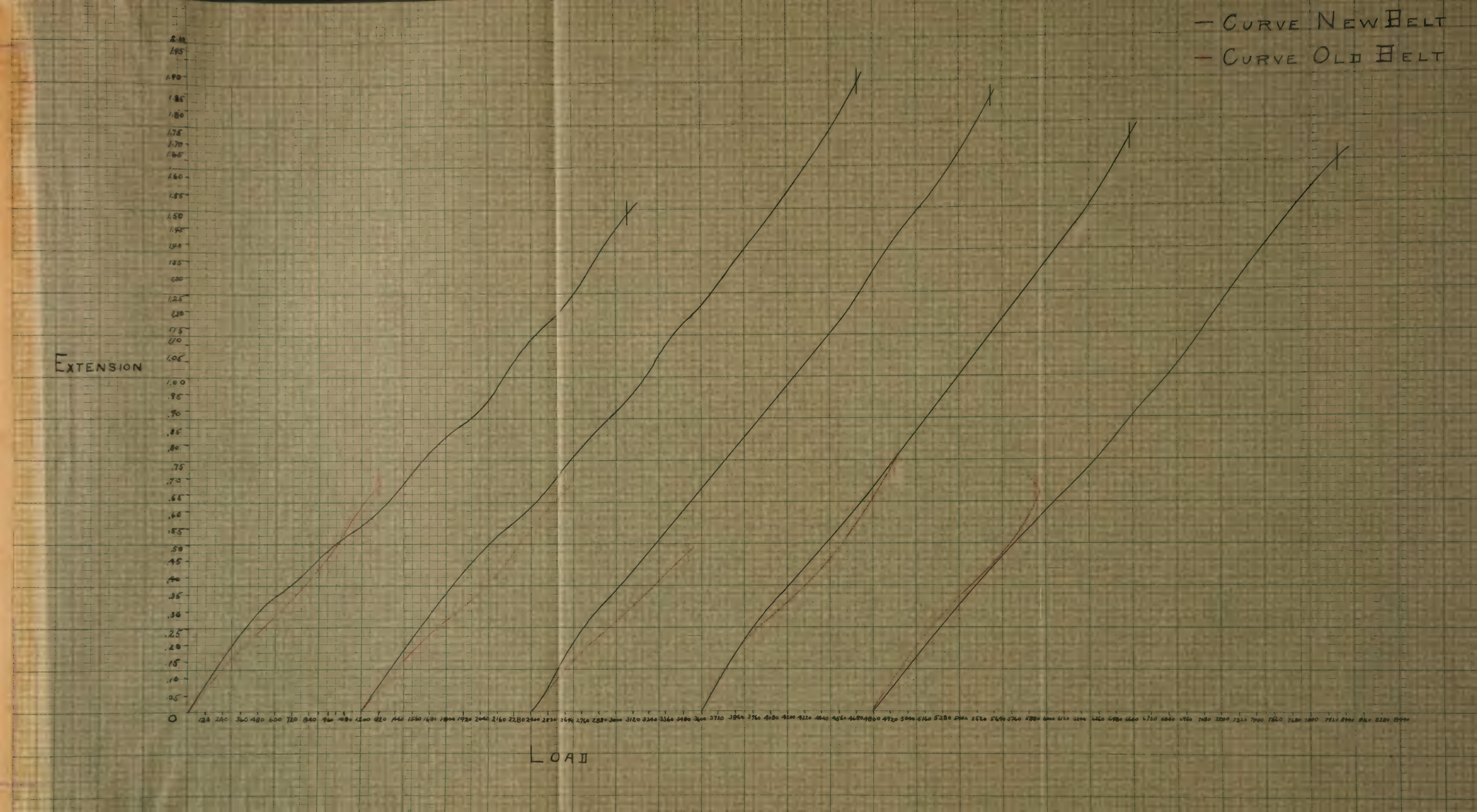


PLATE 2 SCALE 3 IN.=1 FT.

11'		12'		13'		14'		15'	
EXTENS.	LOAD	EXTENS	LOAD	EXTENS.	LOAD	EXTENS	LOAD	EXTENS	LOAD
8.00"	0	8.00"	0	8.00"	0	8.00"	0	8.00"	0
.06	105	.06	100	.07	100	.07	100	.05	105
.13	205	.14	220	.15	215	.15	215	.11	200
.20	305	.20	325	.21	310	.20	300	.17	305
.25	420	.25	410	.26	400	.26	410	.21	410
.29	510	.29	500	.31	510	.31	500	.27	505
.34	615	.35	600	.36	620	.35	600	.31	605
.37	735	.40	710	.40	700	.40	700	.36	715
.41	815	.43	800	.45	815	.44	795	.42	820
.45	915	.49	905	.51	905	.50	890	.45	915
.50	1020	.52	1000	.55	1000	.53	990	.50	1010
.52	1120	.55	1100	.60	1100	.58	1100	.53	1120
.55	1240	.60	1210	.65	1200	.66	1195	.58	1225
.61	1365	.64	1305	.70	1305	.72	1310	.63	1340
.64	1455	.70	1420	.75	1410	.76	1410	.67	1430
.72	1575	.75	1525	.80	1500	.80	1500	.71	1525
.75	1670	.78	1620	.85	1605	.86	1610	.76	1610
.81	1775	.85	1700	.90	1700	.93	1710	.82	1710
.83	1875	.88	1800	.96	1810	.98	1815	.87	1835
.86	1980	.92	1905	9.01	1900	9.03	1910	.91	1925
.91	2090	.96	2010	.06	2000	.10	2030	.96	2025
.97	2190	9.04	2105	.11	2100	.14	2120	9.01	2130
9.02	2285	.09	2200	.16	2200	.19	2215	.07	2225
.09	2400	.15	2315	.21	2305	.25	2315	.13	2340
.13	2500	.19	2415	.28	2400	.28	2410	.19	2450
.16	2605	.23	2500	.35	2530	.35	2510	.25	2545
.22	2705	.29	2615	.41	2600	.42	2605	.30	2610
.28	2800	.32	2700	.46	2700	.47	2700	.34	2740
.35	2915	.40	2800	.50	2800	.55	2845	.40	2815
.40	2995	.45	2900	.56	2910	.66	2990	.47	2930
broke	3105 / 1660	.53	3015	.63	3015	broke	3035	.53	3050
		.57	3100	.70	3130			.60	3150
		.67	3285	.77	3220			broke	3250 / 1935
		78	3440	broke	3265				
		broke	3475						


— Curve New Belt
— Curve Old Belt
Extension
Load

The extension load curve shows a comparison of one piece as 11' of the new piece of belt with a similar piece as 21 of the old belt. The specimens of the new belt are shown in black lines while the specimens of the old belt are shown in red lines. Specimen # 13' out of the middle of the new belt, is the most uniform, approaching very close to a straight line.

all the specimens of the new belt show a fairly uniform curve there being no abrupt changes because the extensions increased proportionally to the load. Care must be taken to balance the beam as the load falls off very quickly, but the

tension remains the same, so that if you desired to increase by nearly regular steps, the beam should be constantly balanced. The elastic limit of the old belt, if it may be so called, was 50# i.e. the beam remained balanced up to that point without dropping; after that point was reached a further increase of load would cause the scale-beam, which had been balanced, to drop. The speed was kept constant during the tests and before each test the zero of the scale-beam was adjusted.

Conclusions.

From the test it was found that the new belt was more uniform in strength than the old belt. On the old belt it was found that the strength was more uniform across the joints, than across the best part of the belt. The sudden drop in the curve page 22, was caused by a weakening of the outside edge of the belt by a peg-hole. On the best part of the old belt, the middle and outer edges were the weakest.

On the new belt, the strength was more uniform across the best part of the belt.

Across the joints, the weakest part was in the middle.

It was found that holes for lacing, pegs, or rivets are weak points in belts, they give the tear a start so that rupture soon follows.

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